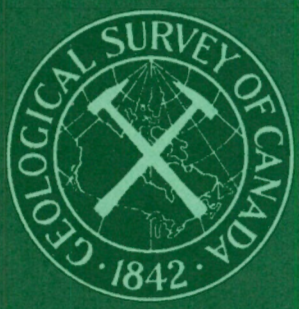

GEOLOGICAL
SURVEY
OF
CANADA

DEPARTMENT OF MINES
AND TECHNICAL SURVEYS

BULLETIN 105

DIABASE-GABBRO SILLS AND RELATED ROCKS OF BANKS AND VICTORIA ISLANDS, ARCTIC ARCHIPELAGO

R. L. Christie

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1964

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By
R. L. Christie

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Plate I. A thick sill changes horizons, west coast of Banks Island. The flat-lying Precambrian beds are overlain by Mesozoic beds and by a thick veneer of glacial debris.

PREFACE

The sills, dykes, and volcanic rocks of Banks and Victoria Islands form some striking and remarkable topographic features. The assemblage includes lavas similar to those of the Coppermine River region on the mainland that have attracted interest in both historic and prehistoric times because of their association with deposits of native copper.

This report presents data obtained during a reconnaissance survey and includes petrographic and palaeomagnetic results. It is complementary to GSC Memoir 330, which describes the general geology of the whole island group.

J. M. HARRISON,
Director, Geological Survey of Canada

OTTAWA, June 7, 1962

Bulletin 105—Die Diabase und Gabbros der Victoria- und Banks-Inseln

Von R. L. Christie

Diabas-und Gabbrogesteine treten in präkambrischen Sedimentgesteinen auf und bilden einen beträchtlichen Teil der Gesamtmächtigkeit der Schichten. Der Bericht enthält auch petrographische und paläomagnetische Angaben.

Бюллетень 105—Диабазо-габбровые пластовые интрузии островов Виктория и Бэнкс.

Автор: Р. Л. Кристи

Диабазовые и габброидные породы находятся в докэмбрийских осадочных горных породах и составляют значительную часть общей мощности пластов. Отчёт содержит петрографические и палеомагнетические данные.

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3. Precambrian formations and diabase-gabbro sills and dykes, southern Victoria Island ..... *In pocket*

DIABASE-GABBRO SILLS AND RELATED ROCKS OF BANKS AND VICTORIA ISLANDS, ARCTIC ARCHIPELAGO

Abstract

Diabasic and gabbroic sills and dykes characterize the Precambrian formations of Banks and Victoria Islands, and contribute considerably to the total thickness of the enclosing sedimentary section. The sills are thickest and most numerous near exposures of the basaltic volcanic Natkusiak Formation. The two groups of rocks are petrographically similar, and presumably are closely related in time and origin. A palaeomagnetic reconnaissance suggests the presence of magnetically stable rocks.

Résumé

Des dykes et des sills de diabase et de gabbro caractérisent les formations précambriennes des îles Banks et Victoria; ils contribuent pour beaucoup à l'épaisseur totale des coupes des roches sédimentaires encaissantes. Les sills sont plus épais et plus nombreux près des affleurements de la formation volcanique basaltique Natkusiak. Les deux genres de roches se ressemblent du point de vue pétrographique et, selon toute apparence, ils sont reliés de très près en ce qui concerne l'âge et l'origine. Un levé paléomagnétique de reconnaissance porte à croire à la présence de roches stables du point de vue magnétique.

INTRODUCTION

Gabbroic sills and dykes are abundant and widely exposed along the Minto Arch and elsewhere in the Precambrian terrain of Banks and Victoria Islands. The youngest member of the stratified Precambrian formations, the Natkusiak Formation, comprises mainly basalt flows and may be related to the sills and dykes. Similar Precambrian intrusive rocks occur in the Coppermine River region on the mainland. The total volume of gabbroic rock represented is prodigious, and the region ranks as a major province of basaltic igneous activity.

Amygdaloidal basalts of the mainland were noted by early explorers because of associated native copper, and the basaltic sill- or dyke-rock which forms certain of the Finlayson Islands was described by John Rae in a letter to G. M. Dawson (1887, p. 34R). From reports by Eskimos of native copper in central Victoria Island, O'Neill (1924, p. 24A and map p. 55A) suspected the presence there of copper-bearing lavas similar to those of the Coppermine River region. F. Johansen, another member of the Canadian Arctic Expedition of 1913-18, discovered diabase on Victoria Island north of the Richardson Islands. In 1930 the diabase-gabbro sills and the volcanic Natkusiak Formation of the Shaler Mountains were accurately identified from the air by W. G. Jewitt of the Consolidated Mining and Smelting Company. A. L. Washburn (1947, pp. 14-20) published this information, together with his own observations made between 1938 and 1941. The basaltic lavas of the Coppermine Series and the associated diabase dykes and sills were mapped in 1959 during a reconnaissance survey by the Geological Survey of Canada (Fraser, 1960).

The sills and dykes were described briefly by Thorsteinsson and Tozer (1961, p. 3), but only three large dykes are shown on their geological map. They also named and described the Natkusiak Formation (1962, p. 37), whose type section is south of Glenelg Bay. The following notes and the accompanying map are supplementary, therefore, to the already published map, and give a fuller description and some graphic measure of the distribution of the basic intrusive and extrusive rocks.

DIABASE-GABBRO SILLS AND DYKES

The thickness and number of these sills contributes considerably to the apparent total thickness of the Precambrian beds. The sills are easily identified by their dark colour, resistance to weathering and erosion, and prominent columnar jointing. The igneous layers form the caps of mesas and cuestas, which are the distinctive landform of the Shaler Mountains (*see* Pls. I to V).

Structural Relations

The sills are commonly between 20 and 200 feet thick, and some are up to 350 feet. Most of them are of strikingly uniform thickness and of great extent, but a few change thickness or terminate abruptly (*see* Pl. I). The intrusive nature of the sills is clearly indicated by the abrupt changes in the sedimentary horizons followed by the sills (Pls. I, II A, III B).

In the Holman Island syncline at least 10 (west of Hadley Bay probably 20) mappable sills are present. If these sills average 150 feet, the total thickness of the intrusive rock would be between 1,500 and 3,000 feet, which is probably a conservative estimate.

Large and small dykes of diabasic gabbro, identical to the sill-rocks, intrude the Shaler and older groups; many of these undoubtedly occupy feeder conduits of the sills. The number of dykes is relatively small. One, at least 6 miles long and several hundred feet wide, forms a conspicuous ridge in the Shaler Group west of Hadley Bay.

Both the Shaler Group of sedimentary rocks and the volcanic Natkusiak Formation are intruded by dykes and sills; sills are, however, difficult to identify in the latter formation. The proportion of intrusive rock in the Natkusiak Formation remains unknown.

The sills are thicker and more numerous nearer the axis of Holman Island syncline than they are farther from it. This association in space may be taken as evidence of close genetic relationship or of contemporaneity of the sills and the lavas.

Petrography

Fresh surfaces of the sill- and dyke-rocks are dark green-grey to blue-grey or almost black; weathered surfaces are dark brown to dark grey-brown. The grain is characteristically fine to medium; borders are fine grained, and in some larger sills medium and coarse, patchy texture may be found. The finer grained rocks may be described as diabases, the coarser as diabasic gabbros or gabbros. Granophyre (coarse grained, with visible potassic feldspar) was observed in some of the thicker sills, particularly on the west coast of Banks Island. No evidence of

differentiation was noted in the field, however, and no systematic sampling was attempted for laboratory study of a section through a sill.

The mineralogy and textures of the sills are typical of diabase-gabbro bodies elsewhere in the world. The prominent minerals are plagioclase, pyroxene, and derived alteration products; the plagioclase is commonly euhedral, and pyroxene occurs as interstitial granules or as enclosing, ophitic grains. The plagioclase characteristically is labradorite. Orthopyroxene is rarely present.

Minor amounts of quartz occur as interstitial grains and myrmekitic intergrowths in about half of the thin sections examined. In a few specimens quartz forms micrographic intergrowths with very small amounts of potash feldspar. The quartz-bearing gabbros appear somewhat coarser grained and more feldspathic than do the quartz-poor varieties.

The quartz-poor, plagioclase-pyroxene gabbros seem inclined to be medium or fine grained, with granular pyroxene.

About one third of the rocks examined are altered olivine-gabbros; olivine is rarely present, but patches and interstitial masses of serpentine, and the shattering of other minerals (presumably due to expansion upon alteration of olivine) strongly suggest original olivine.

Biotite, widespread as brown euhedra, appears to be of magmatic origin, but this is uncertain in some specimens.

Opaque iron ore (magnetite or magnetite-ilmenite) is abundant (up to about 5 per cent of the rock) as large interstitial masses and in some rocks is intergrown with biotite.

Alteration

The pyroxene is more or less altered to green hornblende or, less commonly, to fibrous green amphibole (tremolite-actinolite?). Green chlorite-like secondary biotite is commonly developed in small amounts from the biotite or other mafic minerals, but true chlorite is rare. The more massive hornblende probably represents a late magmatic stage of alteration; the fibrous amphibolite and biotite-chlorite represent a later or secondary stage.

The widespread serpentine-alteration, as already mentioned, presumably is derived from small amounts of magmatic olivine. Plagioclase is invariably more or less replaced by sericite, but its optical properties are rarely completely obscured. Some interstitial quartz associated with plagioclase may be derived from the sericite-alteration. Intergrowths of magnetite-biotite and, rarely, quartz-potash feldspar probably are late alteration phenomena.

Magnetic Characteristics

Hand specimens are noticeably attracted to a small magnet and the needle of a magnetic compass often is violently deflected near an outcrop, due undoubtedly to the considerable proportion of magnetite or magnetite-ilmenite in the rock.

Palaeomagnetic study of nine specimens collected from widely separated localities on Victoria Island was carried out by R. F. Black of the Geological Survey of Canada; his results are shown in Table I. Only four specimens are shown to be stably magnetized, four were doubtful, and one specimen was discarded because of inconsistent magnetic behaviour after treatment. Five specimens were reversely polarized, and three positively or normally magnetized. The directions of magnetization plotted by Black (Fig. 1) show considerable scatter but all are contained in a 120 degree sector between azimuths 185°T and 305°T, and most lie within a sector about 100 degrees wide. The scatter may be attributed to defects in collecting, so that magnetic stability of the gabbros cannot be evaluated. The present pole of magnetization lies, of course, in the northeast quadrant.

Table I

Magnetic Data for Diabase-Gabbro Specimens from Victoria Island

Sample No.	Collection Site Lat. North	Long. West	Reliability	Polarity[1]	Samples Corrected To 71°N D.	110°W I.
A	70.5	118.0	Stable	—	280.5	+ 2.0
B	70.0°	107.5	Doubtful[2]	—	190.0	+33.0
C	69.0°	106.0°	Stable	—	223.0	+16.5
D	71.0°	113.5	Doubtful	—	189.0	+43.5
E	71.0°	114.5	Stable	+	290.0	+ 5.0
F	72.0°	108.5	Doubtful	+	205.0	+ 4.0
G	71.5°	108.5	Stable	+	304.0	+62.5
H	71.5°	112.5	Doubtful	—	285.5	+10.0

[1]For comparative purposes, all vectors have been adjusted to point downward.

[2]Doubtful reliability indicates significant change in direction of magnetic vectors in the specimen after two magnetic washings in alternating current demagnetizing field.

The results seem to indicate remanent magnetic poles in southwest or west quadrants; Black suggests that parts of the intrusive bodies are magnetically stable, and that more detailed collecting may prove rewarding. Because of the wide spacing and limited number of samples, and the rather inexact orienting technique, these magnetic observations cannot be regarded as more than a brief palaeomagnetic reconnaissance.

The mild distortion of the Shaler Group and the sills into an open syncline was not taken into account in orienting the specimens because it is uncertain whether the sills preceded or followed the folding.

Age and Origin

The diabase-gabbro sills and dykes intrude the presumed late Precambrian Shaler Group, but are not found in the overlying Cambrian (?) and Ordovician

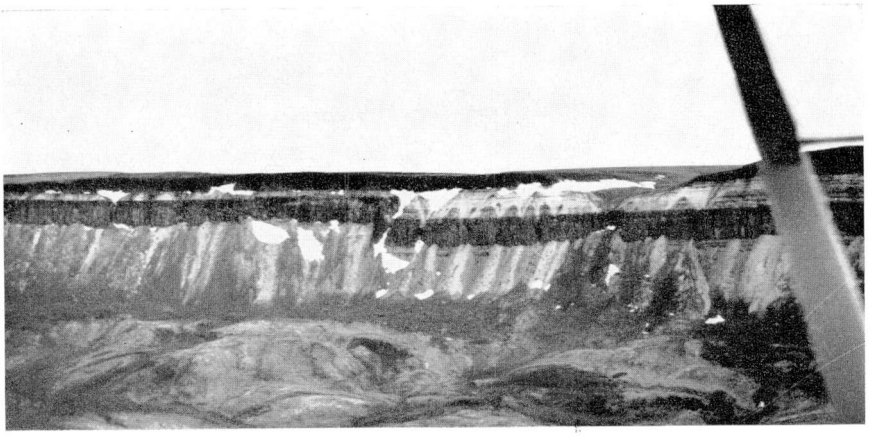

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Plate II. A. Sills in the Kilian Formation south of Minto Inlet. Note the change in horizons followed by the lower sill.

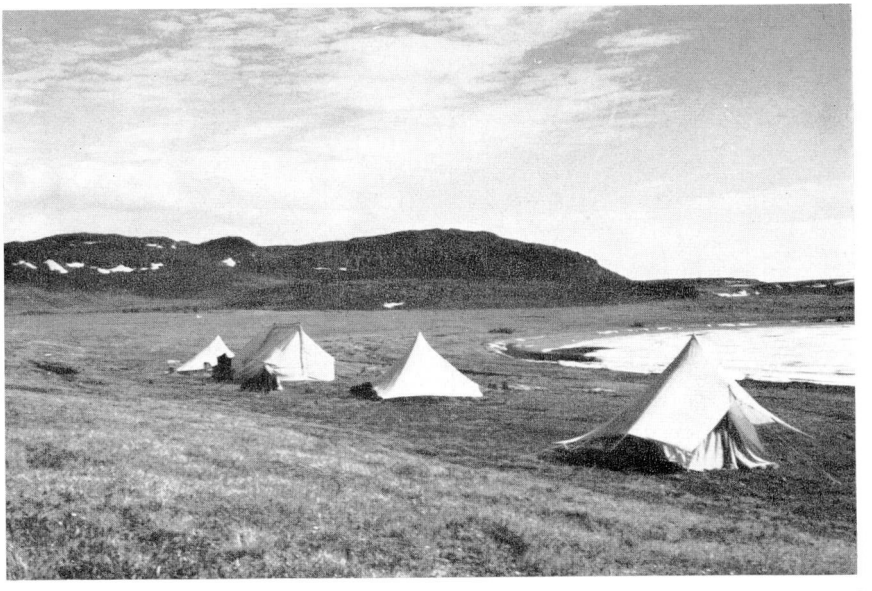

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Plate II. B. Sill-dominated topography at Holman (Hudson's Bay Post). The post lies beyond a low ridge and below the prominent cliffs.

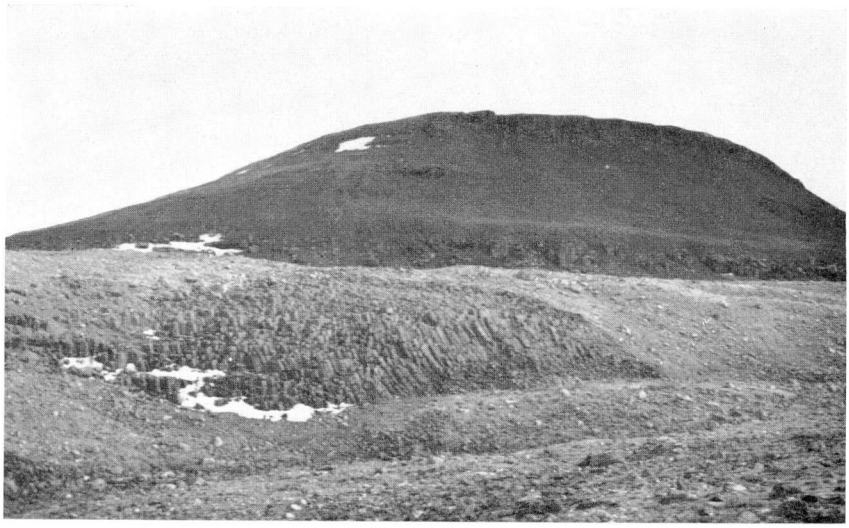

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Plate III. A. Well-developed columnar jointing in a thick sill. The sill follows the base of a grey weathering sandstone bed about 150 feet thick; the sandstone and the overlying Natkusiak volcanic formation are evident in the background. Mountains south of Kuujjua (Minto) River.

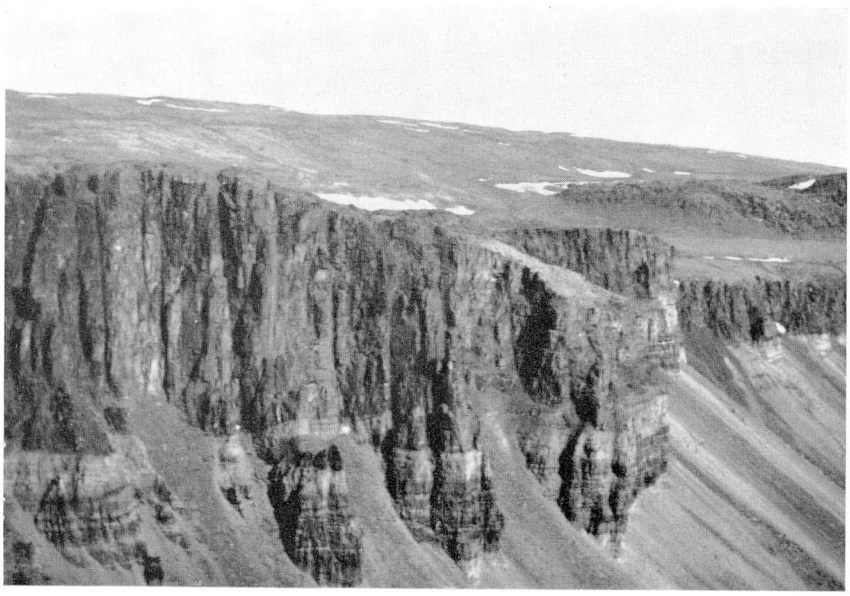

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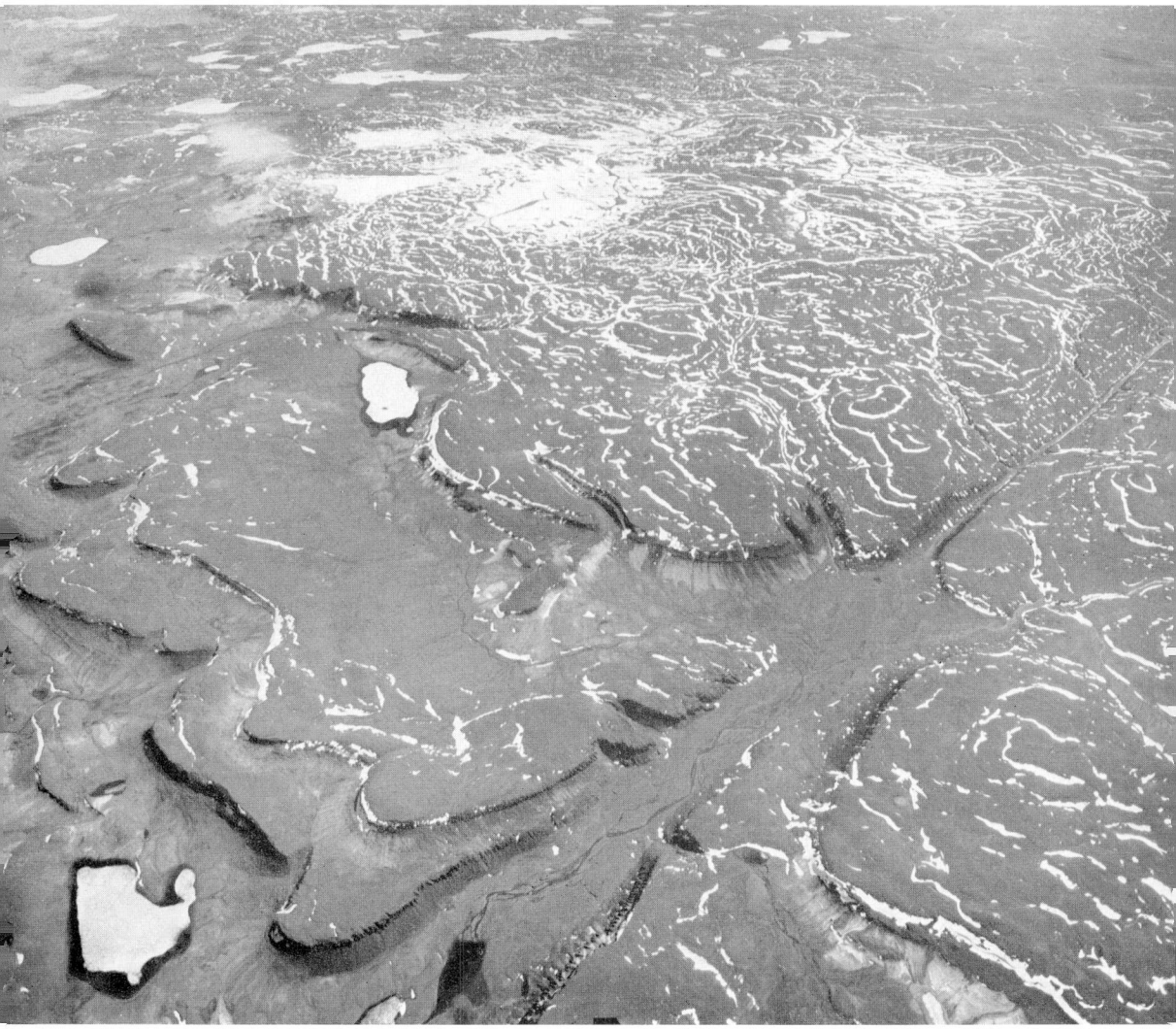
Plate III. B. Typical rude columnar jointing in a thick sill near Cape Lambton, Banks Island. Note the 'sliver' of sedimentary rock partly wedged off by igneous rock at the base of the sill.



RCAF, T486R66

Plate IV. View east across the highest part of the Shaler Mountains, showing the dark weathering Natkusiak Formation, the underlying Shaler Group, and the resistant sills. Note the lineament in the lower right of the photograph.

RCAF, T344L116

Plate V. View east across Glenelg Bay and the sill-capped cuestas of the north end of the Shaler Mountains.

dolomite beds. A late Precambrian age is indicated, therefore, for the sills and dykes.

Whole-rock potassium-argon ages were determined in the laboratories of the Geological Survey of Canada on two specimens of diabase-gabbro[1] collected

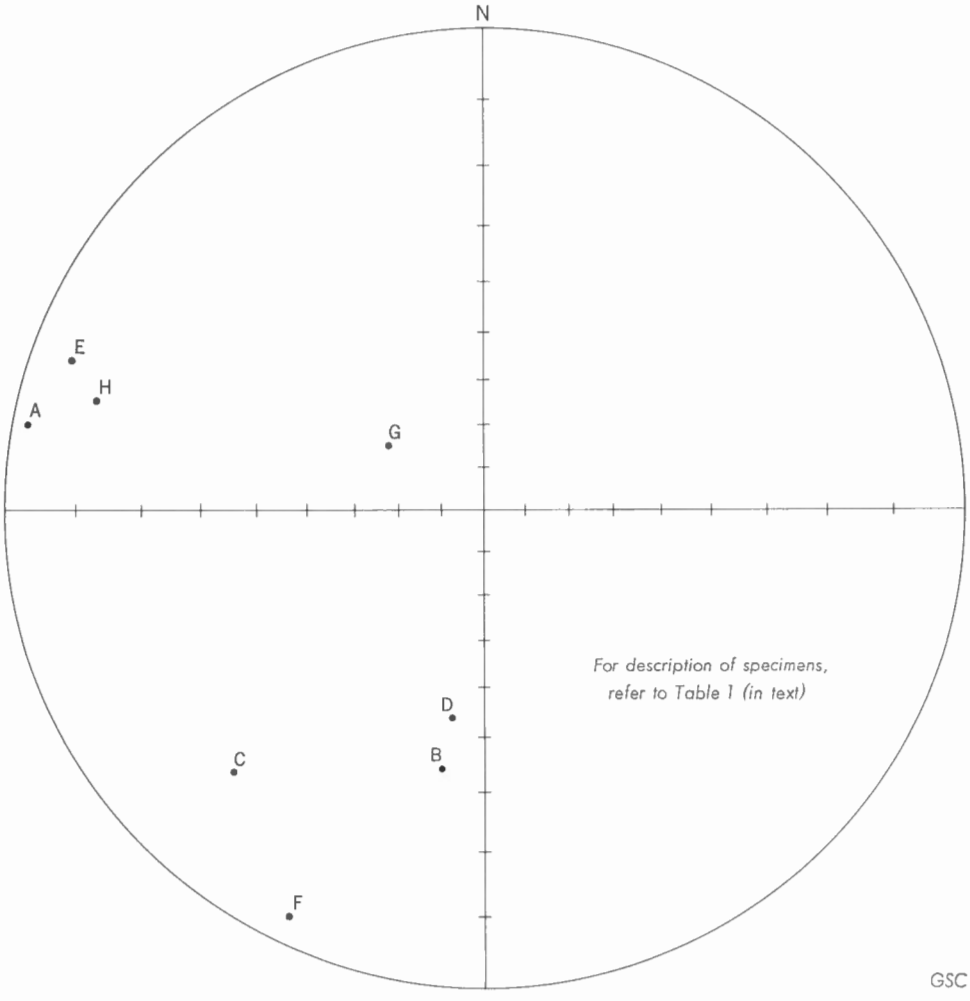


Figure 1. Stereographic projection of directions of magnetization of specimens from Victoria Island.

[1]Petrographic descriptions:
635 m.y. — coarse, sub-granitic texture, with subhedral plagioclase grains and intersertal quartz and quartz-potassic feldspar intergrowth; pyroxene partly altered to hornblende; hornblende partly altered to biotite; and biotite intergrown with magnetite. The quartz-potassic feldspar intergrowth appears to replace or border plagioclase.
640 m.y. — sub-poikilitic, with plagioclase twins partly enclosed in pyroxene-amphibole; pyroxene partly altered to amphibole; chlorite veins cutting plagioclase; intersertal quartz and quartz-plagioclase intergrowths; and biotite, perhaps a secondary mineral resulting from advancing metamorphism.

and submitted by R. Thorsteinsson. The specimens were from a large sill on the northwest side of Glenelg Bay on Victoria Island, and the ages determined are: 635 m.y. and 640 m.y. These figures corroborate the age deduced from stratigraphic data.

Sills and dykes of diabase-gabbro are exposed over large areas in the Coppermine region on the mainland to the south. The intrusive rocks are identical, both lithologically and structurally, to those of the Shaler Mountains, but the enclosing beds of the Coppermine region apparently are not correlatable except in a general way with the Precambrian formations of Banks and Victoria Islands.

An age of 1165 million years has been determined by the Isotope and Nuclear Research Section of the Geological Survey of Canada on rock from the Muskox Complex of basic intrusive rocks (Smith, 1962). Smith describes the Muskox Complex (*see* Fraser, 1960, Map 18-1960) as both transecting and being intruded by diabase dykes of the regional dyke swarm, and suggests that the intrusion was emplaced immediately beneath the basal beds of the Coppermine Series. The dykes of Banks and Victoria Islands presumably may have been contemporaneous with younger dykes of the region.

The texture and composition of the sill-rocks of Banks and Victoria Islands are practically identical (allowing for a difference in grain size) to those of the overlying Natkusiak flows. The uniformity and probable contemporaneity of the sills and flows leave little doubt as to their common origin. The basic composition and the immense volume of magma represented (the present remnants form an unknown proportion of the original outpourings and intrusions) lead one to consider a subcrustal source. It is generally agreed that geophysical data indicate material of about the properties of basalt to lie beneath the lighter or sialic crust.

The characteristic diabase-gabbro composition and texture, the occurrence as a swarm of sills, and the association with a basaltic volcanic formation are typical of the many diabase sill and dyke swarms in non-orogenic continental regions of the world. The exposures of diabasic sills of the Coppermine River region, Darnley Bay, Banks Island, and Victoria Island may be described as occupying parts of a roughly circular area of about 400 miles diameter. Areal extent of this basalt-diabase province may be, therefore, about 120,000 square miles — a figure that would place it in rank with the basaltic terranes of South Africa, Tasmania, and Antarctica.

The similarities of the Coppermine River and Banks-Victoria basalt province to the Lake Superior province have long been noted both from the associated native copper and from petrographic similarities (*see* O'Neill, 1924, pp. 53A, 58A; and Moore, 1929). The present data support close comparison of the two provinces, which are of similar areal extent. In both regions basaltic lavas are associated with quartz-bearing and olivine-bearing diabase, the rocks are late Precambrian, and the volcanic basins are flexed into synclinal structures.

VOLCANIC NATKUSIAK FORMATION

The Natkusiak Formation, named and described by Thorsteinsson and Tozer, comprises about 1,000 feet of dominantly basalt flows, with some tuffs and mixed pyroclastic breccias. It is the youngest formation exposed in the Holman Island syncline, and forms the principal heights of the Shaler Mountains (*see* Pls. III A, IV).

Petrography

The volcanic rocks are equigranular, medium or fine grained, dark green-grey to blue-grey, and uniformly basaltic in appearance. The characteristic texture of basalts, lath-shaped plagioclase crystals in a granulose matrix of pyroxene, is apparent under the microscope. Amygdules are common at the contacts of, and sometimes within, the flows. The amygdules comprise variously carbonate or serpentine with thin coatings of serpentine or serpentine and hematite. The mineralogy of the basalt flows seems essentially identical to the extensive diabase-gabbro sill and dyke rocks of the region.

The breccias vary from coarse dull purple tuff to conglomerate or agglomerate containing cobbles or bombs several inches in diameter. Numerous fragments of limestone and quartzite were observed in dull green-grey agglomerate beds consisting mainly of basaltic fragments in a tuff matrix. There are blocks of sedimentary rocks up to several feet across in a greyish red agglomerate bed at the base of the type section near Glenelg Bay.

Alteration and Secondary Minerals

Secondary minerals are invariably present in conspicuous amounts. Sericite replaces plagioclase; serpentine, serpentine and hematite, or serpentine and magnetite presumably are derived from olivine. Carbonate in small amounts usually is present, and is associated with the serpentine.

Vesicular openings in some flows are filled by quartz (chalcedony)-carbonate and by prehnite[1]. Dark green, micaceous chamosite[1] amygdules with thin coatings of striking turquoise blue celadonite[1] are present in a basalt flow exposed where Minto River cuts through the flank of the Natkusiak Formation.

Hematite fillings in fractures in the flow-rocks apparently are due to a late period of mineralization. Native copper in small quantities is found, but is rare; it occurs both as tiny specks in the rock and as thin patches or strings with hematite in fractures.

---

[1]X-ray identifications by Joan C. Climo, Geological Survey of Canada.

Stratigraphy

The tuff and agglomerate beds, up to about 400 feet thick, lie at the base of the formation but are only locally present. In some sections, the lower few hundred feet of flows appear decidedly amygdaloidal, but in others the entire section apparently is uniform basaltic flows. Typically flows are 100 to 200 feet thick, but in one section nine flows were observed within an interval of 200 feet.

Dykes and Sills

The basalt flows are not easily distinguished from the diabase sills, which are nearly identical in composition and texture. As previously described, sills are found in large numbers immediately beneath the Natkusiak Formation, and they almost certainly are present within the volcanic sequence itself. Basaltic conglomerate overlies medium-grained, columnar-jointed diabase at a locality south of Minto River; the diabase there probably is a sill injected between the basal beds of the Natkusiak Formation and the underlying sandstone bed.

Some basaltic dykes that cut the volcanic flows are easily identified from the air by their horizontal columnar jointing. The dykes frequently occupy lineament-forming breaks in the volcanic and underlying formations. Other dykes are similar in competency and appearance to the lavas, and no lineaments form. The dyke-rocks are identical in texture and composition to the volcanic rocks and to the finer grained sill rocks.

Age

The Natkusiak Formation is presumed to be Precambrian from its conformable relationship with the underlying Precambrian Shaler Group, and from the presence of the diabase dykes, which are not known to intrude nearby Cambrian (?) and Ordovician beds. Corroborating evidence for a Precambrian age is provided by J. A. Fraser (1960, and pers. com.), who describes a basal sandstone probably of Cambrian age and unconformably overlying a diabase dyke north of Great Bear Lake.

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